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Asbestos Fibers in Discharges from Selected Mining and Milling Activities Part III

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ASBESTOS FIBERS IN DISCHARGES FROM SELECTED MINING AND MILLING ACTIVITIES

FINAL REPORT
PART III

JANUARY, 1977

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF TOXIC SUBSTANCES
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16. ABSTRACT

The Office of Toxic Substances of the Environmental Protection Agency has sponsored a nationwide survey to determine the impact of point and non-point sources on levels of waterborne asbestos.

Part I of the final report presented the results of analyses of water from the ten Regional cities.

Part II of the final report presented the results of the analyses of water from natural sources and from point sources manufacturing asbestos products.

Part III of the final report, contained herein, presents the results of the analyses of water from point sources associated with the mining and milling of potentially asbestos bearing rocks.

The results of these analyses indicate that a variety of mineral ore types may have asbestos minerals associated with them and that these fibers are liberated into their effluents. In some instances, however, the final effluent has little impact on levels in the local surface water which already have high asbestos contents.

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ASBESTOS FIBERS in DISCHARGES
from SELECTED MINING and MILLING ACTIVITIES

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Introduction

The Office of Toxic Substances of the Environmental Protection Agency has sponsored a nationwide survey to determine the impact of point and non-point sources on waterborne levels of asbestos.

Part I of the final report presented the results of analyses of water from the ten Regional cities.

Part II of the final report presented the results of the analyses of water from seven natural sources and 22 point sources manufacturing asbestos products.

This report, Part III, presents the results of analyses of water samples taken in and near 6 mining and milling operations in which asbestos minerals may be present. Activities covered were the mining and milling of asbestos, vermiculite, talc, copper and gold.

General Considerations

Rock types in which asbestos minerals might be encountered lie at or near the surface of about 30-40% of the continental United States. These areas also include most of the economically important mineral deposits. Recovery of these minerals, therefore, produces a potential for the release of asbestos fibers to the environment.

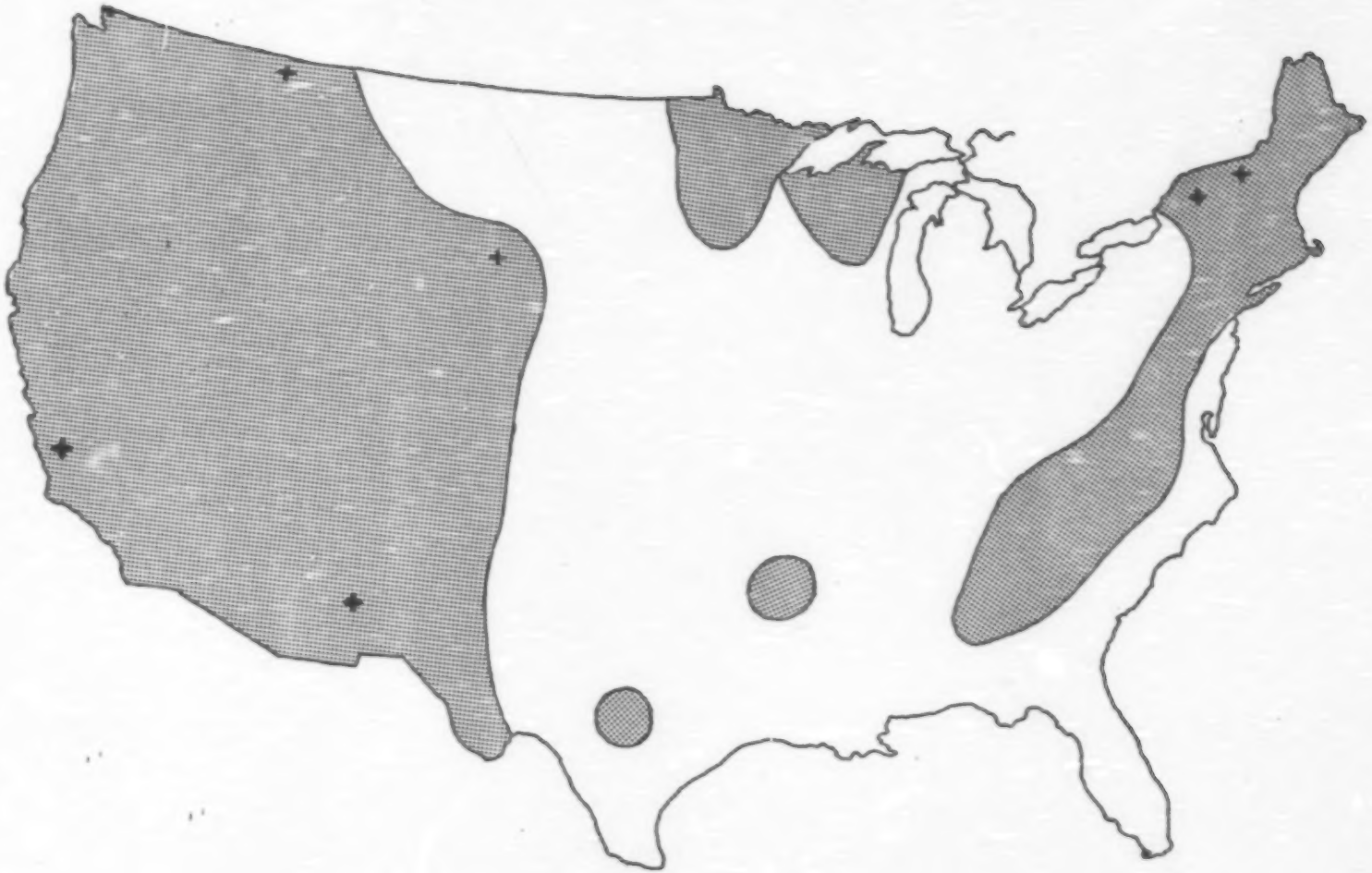
For the purposes of this study the term "asbestos" is used as in the Federal Regulations pertaining to asbestos viz. a particle is defined as asbestos if it has an aspect ratio of greater than 3 to 1 and if it is serpentine, chrysotile, or one of the amphiboles in the generic classes anthophyllite, tremolite-actinolite, crocidolite, cummingtonite-grunerite (amosite).

Within the scope of the present program the selection of sites for study was aimed at establishing the possible extent of this hazard from different types of mining and milling operations rather than at determing the major contributors in this classification. The following activities, whose locations are indicated in Fig 1, were therefore selected.

Site	Type	Site code
Vermont Asbestos Group	Asbestos mining & milling	M2
Union Carbide, Calidria Division King City, CA	Asbestos milling	M3
Phelps Dodge Corporation, Morenci Division	Copper mining	A1
Homestake Mining Company	Gold mining	A2
W.R. Grace & Company, Zonolite Division	Vermiculite mining and processing	A3
Gouverneur Talc Company	Talc mining and milling	A4

Two of these facilities - Union Carbide, Calidria Division and Phelps Dodge Corporation, Morenci Division were found to have no likelihood of effluent to surface waters and were therefore only visited once. The remaining four were visited twice.

It had originally been intended to sample an additional mine, the Union Carbide Mine at Coalinga, CA. Active mining in this area, however, is on a sporadic basis, with intensive mining for a few months once every three years or so with stock piling of the ore. No mining was undertaken at this location during the period of performance of the sampling program.



Location of sites described in this report (crosses)
with respect to areas of potential asbestos bearing rock types (shaded).

Figure 1

Sampling and analysis methods

The method of grab sampling was used throughout the program. Integrated samples were prepared by accumulating aliquots of individual grab samples taken during the period of integration. This method was preferred to automatic methods which generally involve comparatively narrow gauge tubing, valving systems and a "dead space" in their automatic collection chambers which it was felt might result in settling out of suspended solids. Additionally, separate examination of the grab samples gives some measure of the variability of the effluent resulting, for example, from variations in plant operations.

Individual samples were filtered on site in a specially equipped mobile laboratory. Water used, for rinsing glassware and diluting the samples where necessary, was filtered distilled water, purchased en route and filtered in the mobile laboratory using a filtration apparatus reserved solely for this water filtration. Aliquots of the samples were vacuum filtered through 47 mm diameter, 0.45 μm pore size Millipore filters which were then stored in Petri slides for transporation back to the laboratory.

Segments of the filter samples were prepared for examination on the transmission electron microscope by a direct transfer condensation washing method. Nylon support grids were used to minimize spurious background signals during x-ray analysis in EMMA-IV, the combined electron microscope microanalyzer. Repeat samples were selected at random from the test series as a check on reproducibility.

In measuring the samples the criteria for a fiber to be measured and counted were that it should a) have an aspect-ratio greater than 3:1 and b) yield a diffraction pattern of chrysotile or an amphibole. In the event that an amphibole pattern was obtained an attempt was made to identify the amphibole type present on the basis of energy dispersive x-ray analysis.

The sample preparation method and the criteria for the identification of asbestos are substantially identical to those described in the interim procedure developed by EPA for asbestos determination.* It should be borne in

* available from Dr. Charles Anderson, SERL, EPA, Athens, GA.

mind that the application of these identification criteria will result in the omission of some asbestos fibers or, in extreme cases, all of the asbestos fibers from the count due to such factors as overlap and contamination which obscures clear diffraction patterns and modifies the apparent chemical composition. Sample counts under such conditions, therefore, should only be regarded as minimum estimates of the true asbestos fiber count and may be expected to show poorer reproducibility than those from laboratory prepared standards or "clean" systems.

Fiber counts resulting from less than 5 fibers observed must be treated with caution. In general, such numbers are of doubtful significance over possible background levels. In the laboratory situation near zero background may be achievable. In field sampling and filtration, however, background levels can reasonably be expected to be higher and may vary considerably from plant to plant. To place in perspective this question of background, it should be noted that (1) background levels of 2 fibers per grid square have been reported by other workers, (2) this background level is equivalent to 2 fibers per 5 grid squares in the current work which uses nylon grids having a smaller grid opening and (3) when levels are recorded as "below the detection limit" this indicates that no fibers have been observed in an area encompassing at least 40 and occasionally as many as 120 grid squares. The occurrence of 5 fibers in such an area, therefore, would still be at least 1/3 lower than the accepted background of some other workers.

In some instances samples contained asbestos contents which were impossible to count because of the abundance of fibers present. These are indicated in the tables as "too numerous to count" (TNTC) and an estimated fiber content is given. This estimate is based on the equivalent fiber loading for 100 fibers observed in 1 grid square. Although dilution of the sample might seem a ready solution to this problem, many of the TNTC samples had already received extreme dilutions, with effective volumes sampled on the 47 mm dia filter of less than 0.01 ml.

Results and discussion

The results are presented in tabular form in the accompanying Appendices which describe the individual sampling locations. Because of the variety of the operations covered few generalizations can be made from the results. With the exception of the Morenci division of Phelps Dodge, however, all the locations sampled did show asbestos fibers in their effluent. There is no discharge of effluents at Union Carbide's Calidria division at King City nor at W.R. Grace, Zonolite division, Libby, where waste water is recycled after the addition of make up water. Asbestos was present in the streams neighboring mining operations which showed asbestos in their effluent — an observation that is not surprising, as those streams are eroding and carrying detritus from the local rock. As was observed in the natural sites previously studied, the asbestos level of these streams is also highly dependent on seasonal variations in run off and in most cases shows little increase due to the mining operations. Run off or effluent from the mines also fluctuates seasonally as the source of this effluent is principally water which has accumulated in the mine due to seepage or percolation.

Appendices A - F

Appendix A

Vermont Asbestos Group, Inc., Hyde Park, VT — Site Code M2

The Vermont Asbestos Group (formerly GAF Nine Mile Mine) is presently owned by the employees and is a major asbestos producer in the United States. It is located in a rural area about 5 miles southeast of the town of Lowell on Belvidere Mountain. The office at Hyde Park is located about 40 miles south of Lowell. The adjacent mountain is called Serpentine Mountain because of the great predominance of the mineral serpentine containing asbestos fibers. Even though the asbestos concentration is higher than in many other asbestos producing areas it still is less than 5% of the total rock and requires much crushing, grinding and separation.

The mining and milling procedure is at present a dry operation. The source of the upstream water samples is entirely from mountain run-off streams and the volume of water varies with the rain fall.

The downstream water run-off is almost entirely from mine and quarry drainage and, like the upstream run-off, varies with rain fall, water entering the mines and quarry by seepage and percolation. The combined quarry and mine run -off is fed through a swamp area into a collecting pond about one mile distant. The drainage from No. 3 mine was intermittently pumped out into the combined run-off. The discharge water eventually ends up in the Missisquoi River.

The mine was visited on two occasions. The first visit was 15-16 July 1975 and the second one was 8-10 October 1975.

The combined downstream run-off varies from a more normal flow rate of 2 cu ft/sec (~57 liters/sec) noted in the October visit to about 12 cu ft/sec (~340 liters/sec) noted in the July visit.

The upstream samples of two of the mountain streams were grab samples taken by dipping into the flowing streams.

The quarry discharge and mine run-off was collected about 1/4 mile from the office following a weir used to estimate the flow rate. The collecting pond could only be sampled by dipping into the pond at the end of a small

pier near a company owned cabin.

Although the combined effluent from the mining and milling operations contains a very high asbestos fiber content, greater than 10^9 fibers per fiber (f.p.l.) passage of this effluent through the swamp and the settling pond effects a considerable reduction in the fiber content of the pond which on the first visit had an average fiber content of about 10^8 f.p.l. with no fibers >5 μm long and on the second, approximately 3.8×10^8 f.p.l.

The most noticeable feature of the results from this area is the rainfall dependence of the fiber content of the mountain streams. On the first day of the July visit both the streams sampled had fiber contents in excess of 10^8 f.p.l. following overnight rain which had resulted in a heavier than usual flow of run off water. Weather during the 2 days of sampling was fair and warm with the result that the flow rate was markedly reduced on the second day and so too was the fiber content which dropped by 2 orders of magnitude for one stream and a factor of about 50 for the other. In October the stream from Serpentine Mountain had all but dried up and was only sampled on the first day, when no asbestos fibers were confirmed in either stream. The second stream averaged about 50×10^6 f.p.l. on the remaining 2 days of the October visit with very few fibers more than 5 μm long.

Table legend

Location = sampling point

Type = sample type; I = Integrated
G = Grab
(R) = Repeat analysis

fpl = fibers per litre x 10^6
(A) = amphibole
(C) = chrysotile
BDL = below detection limit - detection limit given in parentheses
TNTC = too numerous to count. The figure in the following column is an estimated lower limit based on a figure of 100 fibers per grid square
THL = sample too heavily loaded for examination

>5μm = number of fibers >5μm long (fpl x 10^6)

tss = total suspended solids in mg/l

na = not available

Appendix A

Table A - 1

Key to Sampling Points

U1 Stream run off from Serpentine Mountain

U2 Mountain stream

D1 Combined quarry and mine run off

D2 Collecting pond, away from inlet

TABLE A - 1

See Legend, p. 11

Vermont Asbestos Group, Lowell, VT — Site Code M2

Location	7/15/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted	7/16/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted
U1	G	490(C)	50	8	49	G	10(C)	2.3	5	13
U2	G	280(C)	13	4	64	G	2.8(C)	0.5	8	11
D1	I	TNTC(C)	$\gg 10^9$	39	-	I	TNTC(C)	$\gg 10^9$	2	-
	I(R)	TNTC(C)	$\gg 10^9$	39	-					
D2	I	110(C)	0	1	36	I	95(C)	0	4	24

TABLE A - 2

See Legend, p. 11

Vermont Asbestos Group, Lowell, VT

Site Code M2

Location	Type	10/8/75 f.p.l.	>5μm	tss mg/l	fibers counted	Type	10/9/75 f.p.l.	>5μm	tss mg/l	fibers counted	Type	10/10/75 f.p.l.	>5μm	tss mg/l	fibers counted
U1+	G	BDL(0.25)	-	2	0										
U2	G	*BDL(0.26)	-	6	0	G	53(C)	0	4	33	G	60(C)	1.6	8	38
						G(R)	*BDL(0.13)	-	4	0					
						G	73(C)	0	6	46					
D1	I	1100(C)	32	3	34	I	1700(C)	33	7	52	I	570(C)	16	10	36
D2	I	110(C)	3.2	3	34	I	280(C)	0	8	35	I	750(C)	48	1	47

+ stream almost dry

* Some high aspect ratio fibers noted which did not yield diffraction patterns.

Appendix B

Union Carbide, King City, CA — Site Code M3

The Union Carbide mill located in a sparsely populated area near King City, California produces Calidria® asbestos from the material mined at Coalinga, California. This material is a short fiber asbestos used principally as a filler in such products as vinyl floor tile. The plant is claimed to be unique in the U.S. in that it uses a wet milling process to produce the product.

Water for the process is derived from a well on the site and the effluent, together with storm water, is fed to a deep, steep walled basin. Loss of water from this basin is by evaporation and percolation only with no surface run off or overflow. At the time of sampling (March 1975) there had been some considerable rainfall but the water level in the basin was some distance below the rim and it is difficult to envisage circumstances which might lead to escape of the water to any surface water. For this reason sampling was restricted and only 1 day's sampling was carried out at this site.

During much of the sampling heavy rain was falling and this brought down numerous white specks from the atmosphere which proved to be chrysotile asbestos. These settled on every surface exposed to the rain and could be seen on clothing and trapped in rain drops running down the windows of the van. Material drying out from clothing presented a contamination hazard when personnel entered the vehicle and a high level of chrysotile (130×10^6 f.p.l.) was found in a distilled water blank.

Because of the weather conditions no air sampling was performed outside. An air sampler run inside the mobile laboratory showed no evidence of asbestos. The quantity of material washed out from the atmosphere, however, quite clearly suggests that this plant may well present an air rather than a water problem.

The asbestos level detected in the effluent ditch was in excess of 10^{11} fibers per liter in an integrated sample and could be expected to show some

variation depending on rainfall, the extremes of total suspended solids at this point varying from 515 mg/liter during heavy rain, due to wash out from the earthen walls of the ditch and storm water carrying settled dust, to 32 mg/liter when the rainfall ceased.

Appendix B

Table B - 1

Key to Sampling Points

U1 Water faucet in laboratory

D1 Effluent from plant sampled at open ditch, N.E. corner of electricity sub-station

B1 Filtered distilled water blank

TABLE B - 1

Union Carbide, King City, CA. See Legend p. 11 Site Code M3

3/7/75

Location	Type	f.p.l.	>5 μm	tss mg/l	fibers counted
U1	G	BDL(0.25)	-	15	0
D1	I	TNTC(C)	$\gg 10^{11}$	219	-
B1	G	130(C)	8	na	80

Appendix C

Phelps Dodge Copper Mine, Morenci, AZ — Site Code A1

The Morenci Copper Mine in Greenlee County, S.E. Arizona, is the second largest copper mine in the U.S. processing approximately 150,000 tons of ore per day. The operation at Morenci consists of an open pit mine, a concentrator and a smelter. A considerable amount of water is used, principally in the concentrator. Most of this water is recycled through the 1200 acre settling ponds but additional make up water is required for plant use and domestic use in the towns of Clifton and Morenci. Most of this new water is pumped out of lower Eagle Creek, a tributary of the Gila River, at a point approximately 5 miles west of Morenci. About one-fourth of the water pumped from lower Eagle Creek is natural stream-flow to which rights were established in the early days of mining in the district. Some of the additional water taken from lower Eagle Creek is water pumped from Company wells and discharged into upper Eagle Creek 28 miles upstream from the pump station. The major portion of the additional water in Eagle Creek, however, is water that has been taken from the Black River, a tributary of the Salt River, at a point on the San Carlos Indian Reservation 26 miles northwest of Morenci and pumped over a divide into the upper reaches of Eagle Creek. The area lies approximately 75 miles to the Southeast of the chrysotile mining regions of the Salt River Valley.

Only one visit was made to this site and only three samples were examined. The intake to White Springs reservoir, a local holding reservoir for the water from Eagle Creek, the tailings effluent sampled at the concrete trough carrying tailings from the thickeners to the Tailings Basin, and the Tailings Basin sampled at the recirculation pump identified as at the "back of No. 4 west".

Asbestos fibers were only detected in a rerun of the samples of the White Springs reservoir intake. Agglomeration of both organic and inorganic material was noted in both samples run from this location, making counting difficult, and possibly obscure fibers in the sample recorded as "below detection

limit". The fibers observed presumably originate from the Eagle Creek source. No evidence was found of potentially asbestiform minerals in the rock types in the immediate vicinity of the mining operations and no asbestos was observed downstream of the plant.

Appendix C

Table C - 1

Key to Sampling Points

U3 Intake to White Springs Reservoir

D1 Tailings Launder

D2 Tailings Basin

TABLE C - 1

Phelps Dodge, Morenci, AZ

See Legend, p. 11

Site Code A - 1

3/12/75

Location	Type	f.p.l.	>5μm	tss mg/l	fibers counted
U3	G	BDL(6.3)	-	87	0
U3	G(R)	5400(C)	50	87	32
D1	G*	BDL(2500)	-	11,700	0
D2	G	BDL(5.7)	-	10	0

* Effective vol. filtered = 0.0025 ml. Numerous inorganic fibers observed but are alumino-silicates containing varying amounts of K, Fe and Ca.

Appendix D

Homestake Mining Company, Lead, SD — Site Code A2

The Homestake Mine in South Dakota produces more gold than any other mine in the western hemisphere. Approximately 1.5 million tones of ore is processed each year resulting in a recovery of over 340,000 ounces of gold. Mining and extraction are carried out within the town of Lead in the Black Hills region. Although the towns of Deadwood, Pluma and Center City are within 5 miles of the mine, the population density can still be considered low.

Ore from the multilevel mine is brought to the surface, via 2 shafts — the Yates Mine shaft and the Ross Mine shaft — and is crushed and extracted by the cyanidation process: amalgamation had been used at one time but this process was phased out in an effort to reduce mercury emissions. As shown in Fig D-1, the mine flow patterns are very complex and difficult to follow, having three prime sources for process water and three minor ones. In addition, 20% city water is employed. Recycle water from a settling dam furnishes 48% of the process water; water pumped up from the mines, another 20%; a local stream (Hearst ditch), 6%, and, city water, 20%. City water is obtained from Spearfish Creek at a point about 10 miles north of Lead. Homestake processes the water, uses some in its mining operation and sells the rest to the city of Lead.

The processing plant can actually be divided into two areas for our purposes, the sand plant and the slime or carbon-in-pulp plant.

Crushed ore from the mill is mixed with water, then flows into an east and west sand plant, each containing a series of vats. This is a batch process with several vats in various stages of extraction at a time. The residue from these vats is fed back to the mine for stope filling. Approximately 1.5 mgd (6 million liters/day) of excess water goes to waste. The vat overflow is fed to Dorr thickeners. The clarified overflow from the Dorr thickeners is fed to a settling dam and is then recycled to the mill. The thickened slime is fed to the carbon-in-pulp (slime) plant. The tailings from the slime plant are fed to a nearby stream at a volume of approximately 3 million gallons (12 million liters) per day.

The mine was visited on 16 and 17 June and again on 20 and 21 August 1975.

Water samples were taken representing the 4 major sources, including city water, both finished and at its source— Spearfish Creek north of Lead. Process water was taken at the sand feed to the vats; at the vat drain; the thickener overflow; the slime plant tails; the dam effluent and the stream carrying off the effluent— both upstream and downstream of the discharge.

The operation at Homestake is extremely complex involving two different mine shafts, several levels in the mine, and a batch extraction process. As a result considerable variation is seen in the data from Homestake, with levels of fibrous amphibole varying from below the detection limit to as high as 280×10^9 fibers per liter on different visits to the same location. We believe the results observed reflect process variations and indeed they do appear self consistent for any one day. Thus, although mineral fibers were observed on the first visit, they did not appear to be amphiboles and hence are not classed as asbestos. Instead, the diffraction patterns were hexagonal or pseudo-hexagonal and the chemical composition indicated varying amounts of Mg, Si, Fe and Al. On the second visit a fibrous grunerite-cummingtonite amphibole, Fe rich, was observed on the first day at almost all sampling points whilst on the second day only the pseudo-hexagonal structured fibers were present in the post-process samples.

One must conclude, therefore, that the effluent from Homestake mine will show a varying amount of asbestos fiber, depending on the particular mine level passing through the process line at any one time. As a result, final asbestiform amphibole effluent levels have been observed as high as 280×10^9 fibers per liter from the settling dam but the same location has also yielded samples with no detecteable asbestos.

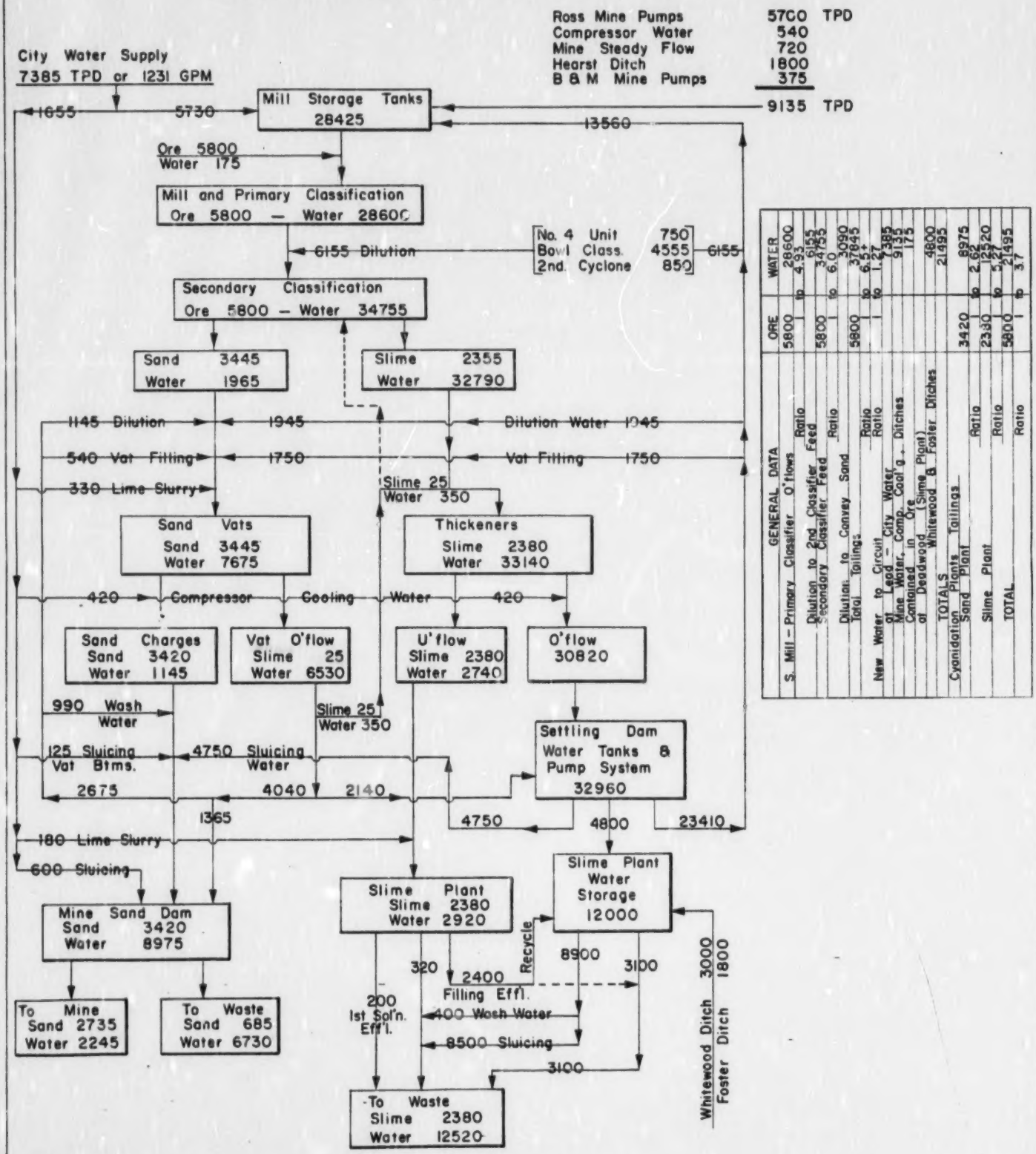
Figure D - 1

Ore and water flow diagram, Homestake Mine,
Lead, South Dakota

HOMESTAKE MINING CO., METALLURGICAL DEPARTMENT, LEAD, S. DAK.

ORE and WATER FLOW DIAGRAM - APRIL 1963

MILLING RATE 5800 TPD - ALL FIGURES TPD



GENERAL DATA	ORE	WATER
S. Mill – Primary Classifier O'flows	5800	28600
Ratio	1 to	4.93
Dilution to 2nd Classifier Feed		6155
Secondary Classifier Feed		34755
Ratio	5800 1 to	6.0
Dilution to Convey Sand		3090
Total Tailings		37845
Ratio	5800 1 to	6.5+
Ratio	1 to	1.27
New Water to Circuit		7385
of Lead – City Water		9135
Mine Water, Comp. Cool'g + Ditches		175
Contained in Ore		
of Deadwood (Slime Plant)		
Deadwood, Whitewood & Foster Ditches		4800
		21495
TOTALS		
Cyanidation Plants Tailings		8975
Sand Plant Ratio	3420 1 to	2.62
Slime Plant Ratio	2380 1 to	5.27
TOTAL Ratio	5800 1 to	3.7

C0158A

Appendix D

Tables D -1, -2

Key to Sampling Points

U1 Hearst ditch (local stream)-source of ~6% of process water

U2 Recycled water from settling dam (48% of process water)

U3 Ross Mine pumps (20% of process water, pumped from mine)

U4 Lead City water (20% of process water)

U5 Spearfish Creek (source of Lead City water)

D1 Slime plant tails

D2 Sand feed (ore slurry) to extraction vats

D3 Extraction vat drain effluent

D4 Clean overflow from Dorr thickeners to settling pond

D5 Stream above Homestake effluent

D6 Dam effluent

D7 Stream below Homestake effluent

TABLE D - 1

Homestake Mine, Lead, SD

See Legend, p. 11

Site Code A 2

Location	6/16/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted	6/17/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted
U1	G	BDL(0.87)	-	13	0	G	BDL(2.1)	-	6	0
U2	G	BDL(1.0)	-	53	0	G	BDL(2.4)	-	47	0
U3	G	BDL(1.1)	-	12	0	G	BDL(0.9)	-	9	0
	G(R)	BDL(1.1)	-	12	0					
U4						G	BDL(0.53)	-	2	0
U5						G	BDL(0.81)	-	5	0
D1	G	BDL(4200)*	-	498,000	0	G	BDL(1500)*	-	727,000	0
D2	G	BDL(390)*	-	285,000	0	G	BDL(450)*	-	739,000	0
D3	G	BDL(0.56)	-	3	0	G	BDL(0.71)	-	2	0
						G(R)	BDL(0.71)	-	2	0
D4	G	BDL(3.3)	-	137	0	G	BDL(2.2)	-	6	0
D5						G	BDL(82)*	-	57,500	0
D6						G	BDL(630)*	-	242	0
						G(R)	BDL(630)*	-	242	0

* only very small vol. filtered (<0.1 ml)

Several of the samples show fibers with a hexagonal or pseudo-hexagonal diffraction pattern, frequently lath shaped and containing Fe, Mg, Al and Si.

TABLE D - 2

Homestake Mine, Lead, SD — See Legend, p. 11 — Site Code A 2

	8/20/75					8/21/75				
Location	Type	f.p.l.	>5μm	tss mg/l	fibers counted	Type	f.p.l.	>5μm	tss mg/l	fibers counted
U1	G	BDL(0.81)	-	8	0	I	21(A)	3.7	7	17
	G	BDL(7.7)	-	1,900	0					
U2	G	21(A)	4.4	26	24	I	380(A)	10.5	43	29
	G(R)	210(A)	36	26	29	I(R)	50(A)	20	43	38
	G	230(A)	59	58	31					
U3	G	42(A)	8.7	57	24	I	270(A)	51	84	32
	G	130(A)	45	220	40					
	G(R)	410(A)	10.6	220	31					
U4	G	BDL(0.25)	-	19	0					

* Amphibole is a high - Fe member of the Cummingtonite-Grunerite series

TABLE D - 2 con't.

Homestake Mine, Lead, SD — See Legend, p. 11 — Site Code A 2

Location	8/20/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted	8/21/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted
D1	G	57000(A)	16000	63100	32	G	260000(A)	37150	4400	42
	G	280000(A)	77250	447000	29					
D2	G	8600	1720	430	15	I	*BDL(63)	-	2700	0
	G	3800	950	129000	12					
D3	G	BDL(0.42)	-	10	0	I	BDL(0.64)	-	1.0	0
	G	BDL(0.43)	-	na	0					
D4	G	100(A)	20	60	31	I	BDL(1.3)	-	88	0
	G	82(A)	9.5	110	26					
D6	G	190(A)	19	70	31	I	BDL(64)	-	3600	0
	G(R)	280(A)	70	70	44					
	G	89000(A)	14000	8300	32					
D7						G	22000	4714	24500	42

* fibers observed - not identified as amphibole - similar to fibers noted in June visit

Appendix E

W.R. Grace and Company, Zonolite Division, Libby, MT — Site Code A3

Zonolite is a major producer of domestic crude vermiculite. Both mining and processing are carried out at sites approximately 10 miles northeast of the town of Libby. The region has a very low population density with no cities of over 10,000 population within 80 miles.

The strip mine and processing plant are situated on a hill in extremely rugged territory. Water is employed in a wet milling operation as well as for carrying the tailings to settling ponds. Local sources supply the water but the system is closed and there is no drainage into nearby streams or rivers. A sieving plant on the shore of the Kootenai River does not use water.

Coarse tailings mixed with water are poured downhill into the first of 2 settling ponds. Fine tailings and water from 2 thickening processes are mixed before entering a distribution manifold at the first settling pond. Fleetwood Creek supplies additional water to the pond which exits via a clarifier and underground conduit downstream of an earthen dam which bounds the pond on the south. After flowing approximately 1/4 mile, the stream empties into the second pond. This pond has no outlet but is fed occasionally by water from Rainy Creek and the Kootenai River. A pumphouse adjacent to this pond pumps water up to a mill make up water tank for reuse.

The mine was visited first on 10 and 11 June 1975 when the weather was clear and dry. There was drizzle and light rain falling on the second visit on 28 and 29 August 1975. It was said to have been a very short and wet summer.

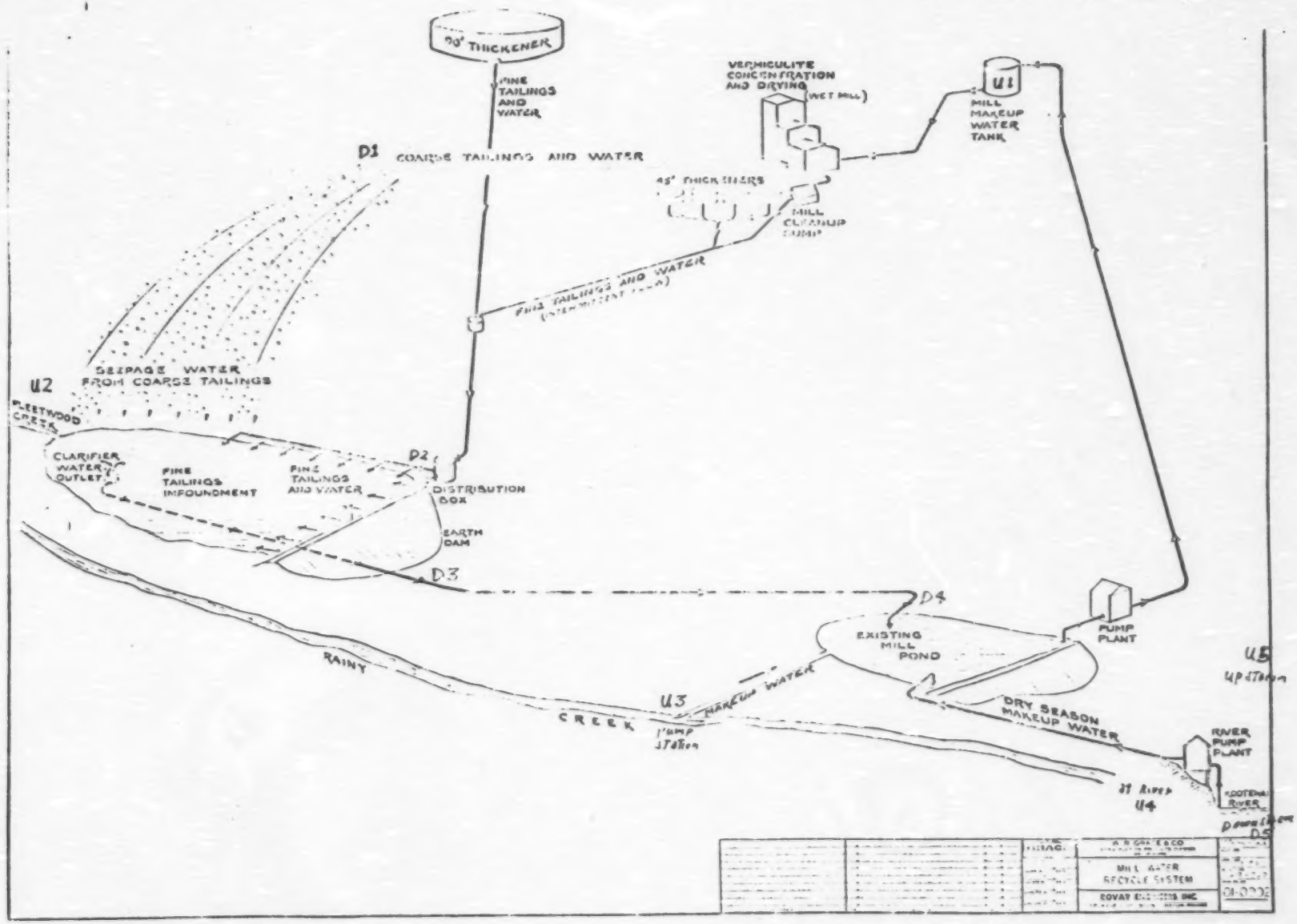
Upstream samples were taken from the mill make up water tank, Fleetwood and Rainy Creeks and the Kootenai River — upstream and downstream of the sieving plant. Downstream samples were taken of the coarse tailings on the hill, the fine tailings entering the first settling pond, the water clarifier outlet from the first pond and second pond. These sampling locations are indicated in the sketch, Figure E -1.

Although substantial amounts of asbestiform amphibole fibers are found in the tailings from the vermiculite mining and milling operation these are effectively contained by the tailings ponds. The first settling pond drops the fiber level by about 3 orders of magnitude to around 10^9 to 10^{10} fibers per liter. The water from this settling pond does not escape but is recycled to the mill and indeed it is necessary to add make up water from the creeks to both settling ponds. The levels of fiber found in the Kootenai River downstream from the dry crusher range from below the detection limit of about 10^6 f.p.l. to about 10^8 f.p.l. These higher levels, however, compare with levels of the order of 10^7 f.p.l. upstream from the plant and 10^9 f.p.l. in Rainy Creek adjacent to the crusher. It is not established whether these high levels in Rainy Creek are due to settled dust from the crusher.

Figure E - 1

Sketch of water cycle

W.R. Grace and Company, Zonolite Division, Libby, MT


70' THICKENER
FINE TAILINGS AND WATER
D1
COARSE TAILINGS AND WATER
VERMICULITE CONCENTRATION AND DRYING (WET MILL)
U1
MILL MAKEUP WATER TANK
45' THICKENERS
MILL CLEANUP SUMP
FINE TAILINGS AND WATER (INTERMITTENT FLOW)
SEEPAGE WATER FROM COARSE TAILINGS
U2
FLEETWOOD CREEK
CLARIFIER WATER OUTLET
FINE TAILINGS IMPOUNDMENT
FINE TAILINGS AND WATER
D2
DISTRIBUTION BOX
EARTH DAM
D3
D4
EXISTING MILL POND
PUMP PLANT
U5
UPSTREAM
RAINY
CREEK
U3
PUMP STATION
MAKEUP WATER
DRY SEASON MAKEUP WATER
RIVER PUMP PLANT
KOOTENAI RIVER
U4
DOWNSTREAM
D5
MILL WATER RECYCLE SYSTEM

Appendix E

Table E - 1

Key to Sampling Points

U1 Mill make up water from 2nd settling pond

U2 Fleetwood Creek - make up water to 1st settling pond

U3 Rainy Creek - make up water to 2nd settling pond

U4 Rainy Creek at Kootenai River

U5 Kootenai River, 1.9 miles upstream of sieving plant

D1 Coarse tailings at top of hill

D2 Fine tailings as they enter 1st settling pond

D3 Effluent from 1st settling pond, leaving clarifier outlet pipe

D4 Water entering 2nd settling pond

D5 Kootenai River about 1 mile downstream of sieving plant

TABLE E -1

W.R. Grace & Co., Zonolite Division, Libby, MT

See Legend, p. 11

Site Code A3

Location	6/10/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted	6/11/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted
U1	G	1700(A)	383	5	71	G	1600(A)	448	4	100
U2	G	BDL(0.64)	-	3	0	G	BDL(1.0)	-	3	0
U3	G	27(C)	2.25	2	12	G	170(A)	60	1	31
		82(A)	8.75	2	37	G(R)	4.1(C)	0.68	1	6
							2.0(A)	2.0	1	3
	G(R)	2.2(C)	0	2	3					
		2.2(A)	0	2	3					
U4	G	190(A)	46	7	37	G	1800(A)	1140	53	41
U5 surface	G	BDL(1.3)	-	20	0					
mid depth	G	BDL(1.1)	-	12	0					
bottom	G	BDL(1.3)	-	10	0					

TABLE E - 1, con't.

See Legend, p. 11

W.R. Grace & Co., Zonolite Division, Libby, MT

Site Code A3

Location	6/10/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted	6/11/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted
D1	G	27000(A)	14300	1758	85	G	150,000(A)	111,000	26,400	31
D2*						I	970,000(A)	502,000	45,000	27
D3*						I	810(C)	0	23	31
							160(A)	27		6
D4	G	840(A)	270	20	53					
D5 4'	G	BDL(0.74)	-	18	0					
2'	G(R)	BDL(0.84)	-	18	0					
1/2'	G	BDL(1.3)	-	21	0					
	G(R)	BDL(1.3)	-	21	0					

* D2 and D3 samples integrated over approximately 23 hrs - 6/10/75 - 6/11/75.
D3 difficult to count due to aggregation. Chrysotile occurs in "aggregated groups", all <1.5μm long.

TABLE E - 2

See Legend, p. 11

W. R. Grace & Co., Zonolite Division, Libby, MT

Site Code A3

Location	8/28/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted	8/29/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted
U1	G	380(A)	157	17	29	G	960(A)	76	15	38
	G(R)	710(A)	158	17	27					
U2	G	3.1(A)	1.24	8	5	G	BDL(1.0)	-	7	0
						G(R)	4.8(A)	1.38	7	7
U3	G	430(A)	190	25	34	G	*800(A)	340	32	47
U4	G	2300(A)	657	473	28	G	6700(A)	1884	211	32
U5	G	2.6(A)	1.3	4	2	G	12	8.8	1	19
	G(R)	BDL(1.3)	-	4	0					

* Uneven loading - count may be high

TABLE E - 2, con't.

W.R. Grace & Co., Zonolite Division, Libby, MT

See Legend, p. 11

Site Code A3

Location	8/28/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted	8/29/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted
D1	G	90000(A)	50000	45,900	38	G	160000(A)	97000	1390	38
D2						I	700000(A)	400000	59500	44
D3						I	1200(A)	357	54	74
D4	G	850(A)	233	39	51	G	860(A)	340	22	53
D5 8'	G	BDL(1.3)	-	4	0					
4'	G	0.64(C)	0.64	2	1	G	13(A)	3.4	1	19
		6.1(A)	2.7	2	9	G(R)	320(A)	93	1	24
2'						G	48(A)	17	na	28
1/2'		BDL(0.64)	-	5	0	G	22(A)	12	9	26

Appendix F

Gouverneur Talc Company (a Subsidiary of R.J. Vanderbilt Company), Gouverneur, NY — Site Code A4

The Gouverneur Talc Company is a major talc mining and producing company. The mine is located in a rural area about 5 miles east of Gouverneur near the small town of Balmat, New York. The talc is mined from open pit as well as deep mines. It is crushed, graded and finally powdered by dry grinding methods and no water is used in processing.

The plant obtains its upstream water supply from Lake Sylvia.

Water discharged from the mill of the plant is largely condensate and cooling water from the boilers. Water collects in the deep mines and varies in quantity depending on rainfall and seepage. This seepage water from the three mines is pumped out intermittently and, following natural streams, eventually ends up in the Oswegatchie River. During discharge water flow from mine No. 1 averages about 75 gal/min, mine No. 2 averages about 90 gal/min and mine No. 3 averages about 100-120 gal/min.

The plant was visited twice. The first visit was made 11-14 July 1975 and the second visit on 3-4 November 1975.

The upstream water was sampled at Lake Sylvia. The downstream water discharged from the mill was sampled as it was discharged into a small stream near a railroad siding not far from the main office. The discharge water from the No. 1 deep mine was sampled as it emerged from the outlet pipe to which it was pumped. The open pit No. 2 mine was located about 1-2 miles northeast of the office and the discharge was sampled here as it emerged from the pipe which led down into the pit. The water from old No. 3 mine located about 5-7 miles east was sampled as it emerged from the pipe into a small sump.

The Gouverneur talc body is an extremely complex ore body mineralogically, showing admixtures of talc, tremolite, anthophyllite and serpentine in varying proportions with associated minerals such as chlorite, magnesium and calcium carbonates, pyroxene and quartz. Some of this complexity is reflected in the analytical results in which 2 amphiboles have been observed — an anthophyllite

type and a tremolitic type. Two serpentines were also seen — antigorite, a non-asbestiform variety, and chrysotile. The levels detected were quite variable, in the range from below a detection limit of approximately 10^5 fibers per liter to in excess of 10^8 f.p.l. some of this variability due no doubt to the intermittent nature of the discharges.

Appendix F

Tables F - 1, -2

Key to Sampling Points

U1 Lake Sylvia

D1 Mill effluent - mainly condensate cooling water from boilers

D2 Drainage water from No. 1 deep mine

D3 Drainage water from No. 2 open pit mine

D4 Drainage water from old No. 3 mine

TABLE F - 1

Gouverneur Talc Company,
Gouverneur, NY

See Legend, p. 11

Site Code A4

	7/11/75					7/14/75				
Location	Type	f.p.l.	>5μm	tss mg/l	fibers counted	Type	f.p.l.	>5μm	tss mg/l	fibers counted
U1	G	BDL(0.13)	-	6	0	G	40(C)	8.7	6	32
	G(R)	BDL(0.13)	-	6	0					
D1	G	230(C)	5.4	62	43	I*	210(C)	10.0	25	42
		310(A)	21	62	59					
D2	G	2.2(C)	0.08	15	26	I	320(C)	0	14	38
							17(A)	8.5	14	2
D3+	G	BDL(0.08)	-	41	0	I	BDL(0.13)	-	26	0
D4	G	1.9(C)	0	12	15	I	32(C)	4.8	9	40

+ Both D3 samples show large agglomerates rendering analysis both difficult and questionable, but no positive asbestos observed.

* Large lathlike or platy fibers present containing Mg & Si, giving pseudo-hexagonal diffraction pattern, not identifiable as asbestos.

TABLE F - 2

Gouverneur Talc Company,
Gouverneur, NY

See Legend, p. 11

Site Code A4

Location	11/3/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted	11/4/75 Type	f.p.l.	>5μm	tss mg/l	fibers counted
U1	G	BDL(0.13)	-	2	0	G	20(A)	4.5	6	39
D1	G	8.4(C)	0	32	5	I	82(A)	13	15	31
		64(A)	20	32	38					
D2	I	30(A)	5		30	I	BDL(0.13)	-	4	0
D3	I	BDL(0.13)	-		0	I	54(A)	16	10	34
D4	G	5.9(C)	0	18	7	G	TNTC(A)	$\gg 10^8$	22	-
		28(A)	5.9	18	33	G	TNTC(A)	$\gg 10^8$	7	-